BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: Jettisonable Enclosure for Unmanned AAP Payloads

DATE: September 30, 1968

FROM: W. W. Hough

ABSTRACT

The advantages, disadvantages, and technical problems associated with contending enclosure configurations and jettison techniques are discussed and compared. On a purely technical basis, clam-shell jettison of the Apollo SLA and a new, split nose cone appears preferable to over-the-nose jettison of the MSFC 203 type enclosure. The segmented SLA-nose cone configuration has at least a 300 pound payload-to-orbit advantage, and its influence on the payload environment is well understood and has been factored into payload designs.

The MSFC 203 type enclosure, however, offers a significant cost advantage. For one test and two flight units, the Apollo Applications Program could save about 4.2 million dollars by implementing the MSFC proposal. Estimated unit costs of additional enclosures for the backup payloads are 0.3 million for a MSFC enclosure vs. 1.2 million for a clam-shell SLA-nose cone.

The decision as to which of the contending configurations is accepted can rest on a determination of whether 600 to 1200 pounds additional payload in orbit, split between AAP-2 and AAP-4, is worth over four million dollars.

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BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: Jettisonable Enclosure for Unmanned AAP Payloads
Case 620

DATE: September 30, 1968

FROM: W. W. Hough

MEMORANDUM FOR FILE

The payload enclosures on the unmanned launches of the Apollo Applications Program, AAP-2 and AAP-4, are to be jettisoned at approximately 180 seconds after lift-off. Sub-orbital jettison of an enclosure offers substantial improvement in the payload-to-orbit capability of each launch. It has not been determined what the configuration or method of jettison of the enclosures will be. There are four configurations and three techniques for jettison during powered flight in contention:

Configuration	Technique	Figure
Apollo SLA-nose cone-tower jettison motor	One piece over the nose	1
Apollo SLA-new segmented nose cone	Four piece clam-shell	2
Apollo SLA-nose cone-tower jettison motor	Five piece combination; nose cone axially, then SLA panels laterally	3
SA 203 type shroud-tower jettison motor	One piece over the nose	4

The two factors which should finally dictate the selection of one of the contenders are impact on launch vehicle performance capability and total cost to the program.

SLA

The basic advantage of the SLA is that it is a known quantity. Its influence on the payload environment from standpoints of interface loads, vibration levels, and acoustic sound pressure levels have been recognized and factored into the design of the payloads--particularly the Airlock Module and the LM-A. Its weight, as it affects performance capability, is firmly established. Ground support equipment (GSE), such as

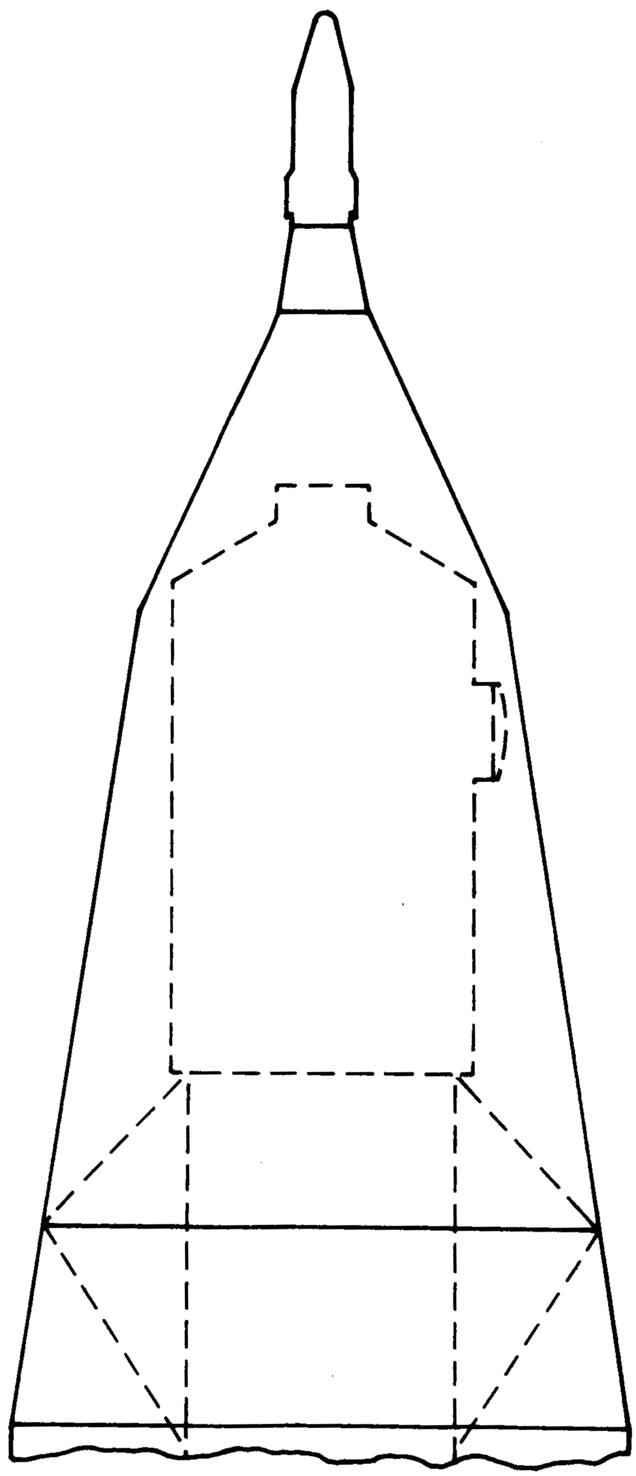

FIGURE 1: APOLLO SLA - NOSE CONE
OVER-THE-NOSE JETTISON

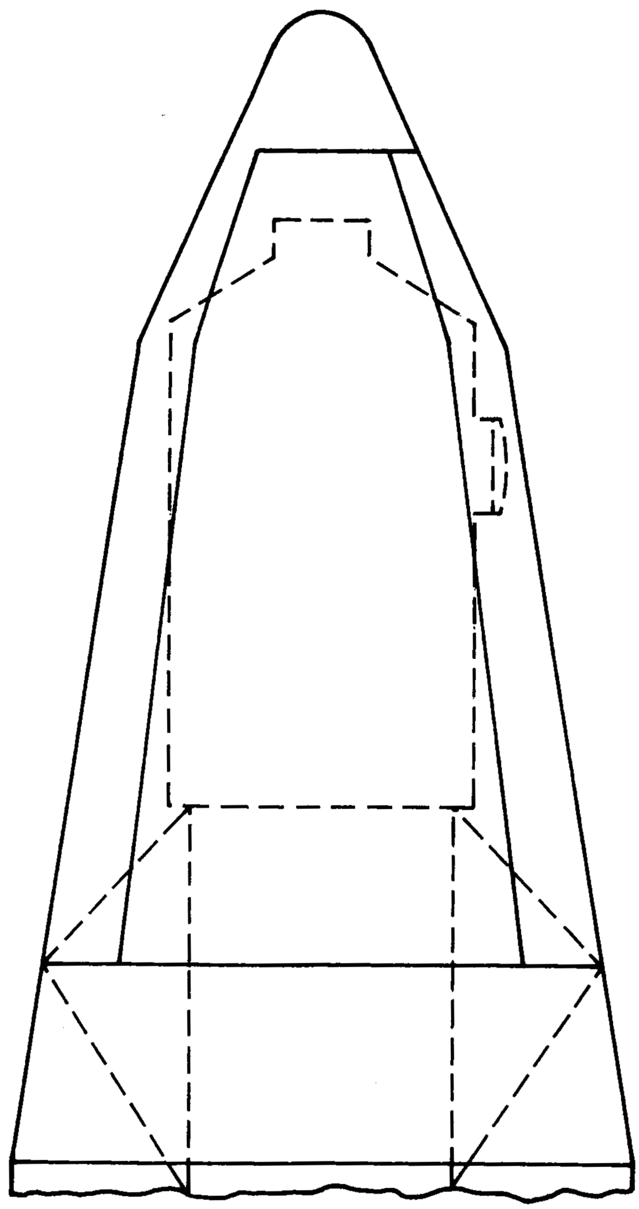

FIGURE 2: APOLLO SLA - SPLIT NOSE CONE
FOUR PIECE CLAM-SHELL JETTISON

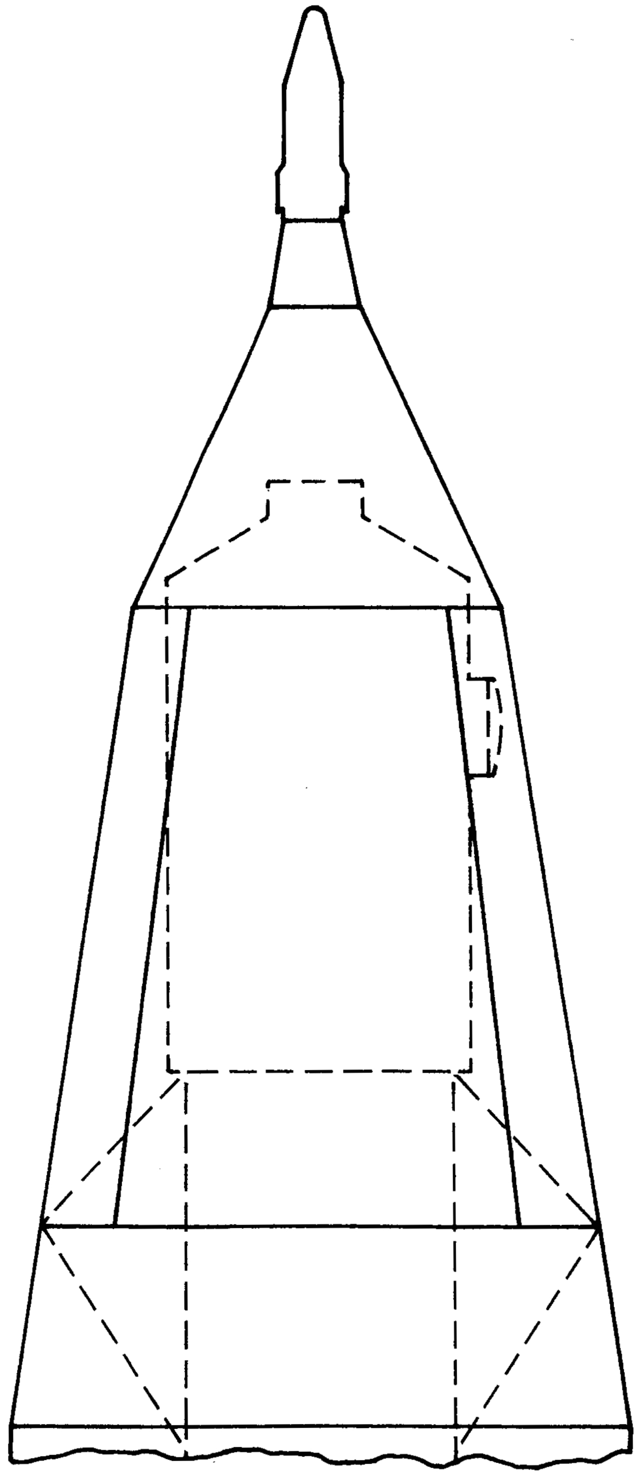

FIGURE 3: APOLLO SLA - NOSE CONE
FIVE-PIECE COMBINATION JETTISON

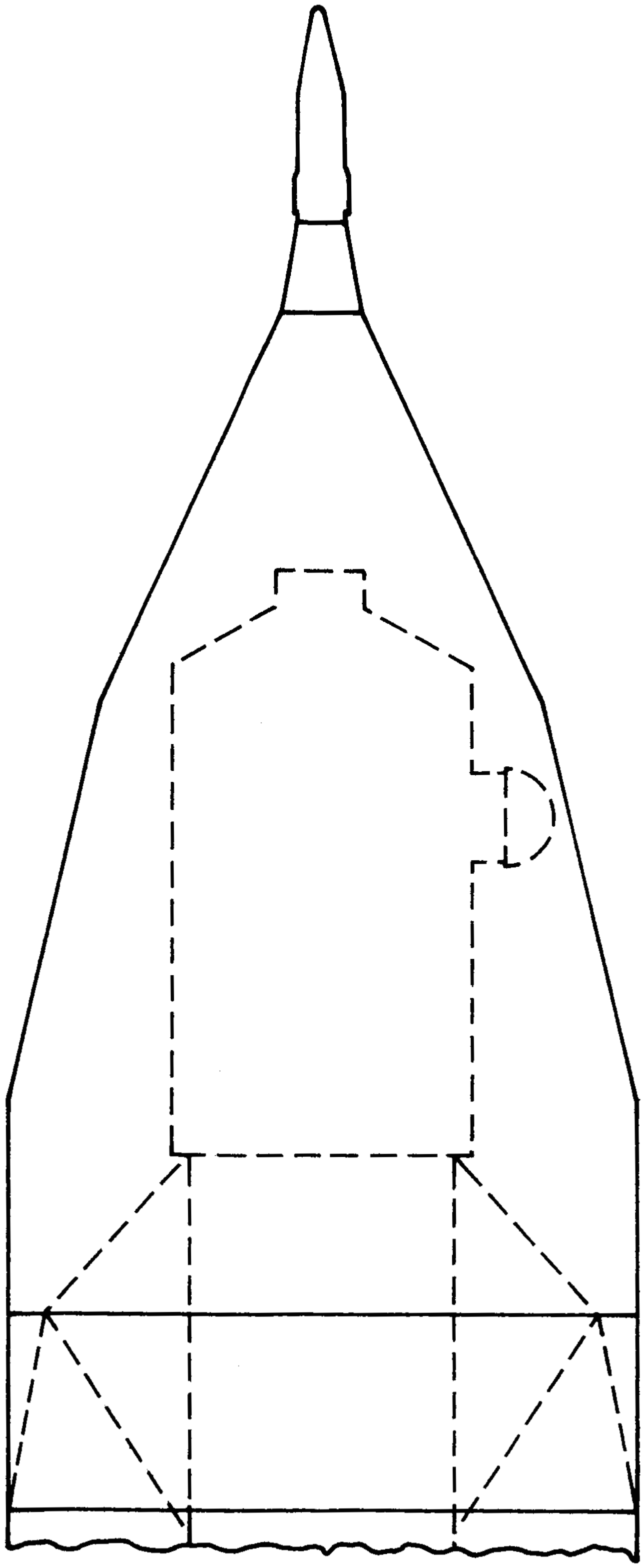

FIGURE 4: SA 203 TYPE ENCLOSURE
OVER-THE-NOSE JETTISON

internal work platforms and handling equipment, lifting fixtures, and test equipment is available from Apollo and requires little or no modification.

A problem which requires resolution if the SLA is used is the insufficient clearance between its inner skin and the jettisonable cover for MDA Port 1. A cover is needed to protect docking interface seals from a long exposure to the space environment, and to provide a pressurized volume for installation of the probe by the AAP-3 crew. If this cover is made large enough to permit probe installation without a change in cover geometry, there is an interference of about 14 inches which must be eliminated by a blister on the SLA. If the over-the-nose jettison technique is used, this blister would have to extend down the SLA to about its separation plane, and would thus be a major modification. With lateral panel jettison, the blister could be a local one. An MDA cover that can be deployed after launch relieves this interference problem, but yields only one-half inch nominal clearance, which is insufficient. Sufficient clearance can be achieved by a small blister on the SLA, or by shortening the MDA tunnel by 3 1/2 inches. A 3 1/2 inch shorter MDA tunnel will give the same clearances during docking that existed before a recent 3 1/2 inch extension of the LM tunnel, except for a docking target that can be relocated or shock mounted.

Though none of the techniques for suborbital jettison of the SLA are beyond conceptual design, no other technical problems are anticipated with any of the approachs. The clam-shell technique offers about 100 pounds greater performance capability than over-the-nose or combination techniques because the tower jettison motor is not required. New panel thrusters (contained gas expansion) to drive the four individual panels over center are required for clam-shell or combination jettison because of launch vehicle acceleration. A clam-shell nose cone must split into four pieces by extension of the existing SLA pyrotechnic trains. Successful jettison of the individual SLA-plus-nose-cone panels can be reasonably demonstrated in an altitude chamber test, whereas a ground test of over-the-nose or combination jettison is not feasible. Because combination jettison is the most complex to implement, and has most of the disadvantages of the other two, it is the least attractive. Because the clam-shell technique is less risky from the standpoint of collision during jettison, because it lends itself to qualification, and because of greater payload capability, it is preferred technically to the over-the-nose technique for SLA jettison.

<u>SA 203 Type Enclosure</u>

The Marshall Space Flight Center has recently proposed that the SLA be replaced by an enclosure of the type used for the SA 203 mission. It would be fabricated in-house at MSFC using skin-stringer construction. The upper-conical sections would be identical in shape to the 203 nose cone, but skin gages would be reduced. Two new cylindrical sections separated by a pyrotechnic joint are required between the IU and the lower conical section. Only over-the-nose jettison using a tower jettison motor has been examined.

The increased diameter of this configuration permits installation of a Port 1 MDA cover of sufficient size for probe installation. It also affords greater clearances during jettison than an over-the-nose SLA configuration.

The additional three feet between the IU and the spacecraft attach points required in the AAP-4 mission can be incorporated directly into the lower cylindrical section, and the procurement of an IU structure from IBM, which is planned with the SLA configuration, is not required. The flexibility for locating GSE interfaces, such as umbilical plates and access doors, so they are compatible with Launch Complex 37B and the integrated test stand at the Manned Spacecraft Operations Building for both AAP-2 and AAP-4 is an advantage. This flexibility in fabrication avoids the requirement to relocate swing arms and external work platforms at KSC between missions.

There are also some recognized technical disadvantages with the MSFC proposal. The fatter shape leads to increased drag, and performance capability is 100 pounds less than the SLA-nose cone-tower jettison motor configuration, if both jettisoned and non-jettisoned weights are equivalent. However, the weights of both are expected to be higher than the SLA. The attenuation of external acoustic pressure at liftoff through the .040 inch skin of the proposed enclosure is less, by about 8 dB overall, than through the honeycomb SLA. As the payloads are designed to the internal SLA environment, a method must be found to further attenuate the sound pressure level. Several concepts are under study, with the most attractive being a helium instead of nitrogen purge of the enclosure on the pad. This approach will probably not give the full 8 dB noise reduction, and the addition of a foam or other attenuating material might be required. Weight estimates for attenuating materials range from 100 to 700 pounds, which translate into 30 to 200 pounds payload loss. The larger diameter at the spacecraft attach points requires additional structure to transmit interface loads to the fixed portion of the enclosure and distribute these loads to an approximately uniform distribution at the IU interface. MSFC's present concept of four 30 pound shear webs is not considered reasonable by this author in view of the fact that these webs must support over 25,000 pounds of payload under an acceleration of over 4 g's. It is estimated that the lower structure, which is not jettisoned, will be at least 100, and possibly several hundred pounds heavier than the lower SLA.

New GSE, rather than modified or usable Apollo GSE, will be required to support the MSFC enclosure. Existing lifting fixtures, internal work platforms, and MSC acoustic test ducts are not usable. There will also be re-analysis of interface loads and structural capabilities of the Airlock Module required at McDonnell.

Technical Comparison

The technical problems of both the SLA and the 203 type enclosure can be solved. Clearance between Port 1 of the MDA and the SLA are sufficient if a deployable cover is used on a 3 1/2 inch shorter tunnel. The best approach for solving the acoustic problem on the 203 type enclosure has not been determined, and the solution might result in a performance loss. The flexibility of the 203 type enclosure is an advantage from the standpoint of no change to KSC facilities between missions, but its new shape forces design and manufacture of some new GSE. The test programs for each do not appear significantly different, but there will be minor additional tests for investigation of fixes for the acoustic problem of the 203 type, and equipment at MSC for the composite acoustic tests would have to be modified for the new shape.

The launch vehicle performance capability using the 203 type enclosure is expected to be 300 to 600 pounds less than the capability using a clam-shell SLA, (200 to 500 pounds less than the capability with an over-the-nose or combination SLA). This, plus the fact that the influence of the SLA on the payload environment is well understood and has been factored into payload design leads to a purely technical preference for a SLA-split nose cone configuration jettisoned by the clam-shell technique.

Cost Comparison

The cost estimates given below are based on three payload enclosures--one for test and two for the prime flight payloads. Two additional enclosures may be required for the backup payloads, and therefore costs for five units are also given.

The first question is whether SLA's will be available from the Apollo Program at no cost to AAP. There are presently two more SLA's in the Apollo Procurement Plan than there are flight CM-SM's. However, Apollo is expected to cut the last two items in their cost reduction program, and AAP can therefore expect to pay for all SLA's it uses on unmanned payloads. A SLA in the Apollo configuration costs 0.86 million dollars (M). The cost of AAP modifications (paid to a contractor) which includes engineering, test, and fabrication of kits for three units is on the order of 3.3 M. There is not a significant difference between the costs of the three configurations. North American and McDonnell have reached opposite conclusions as to whether clam-shell or over-the-nose is the more expensive, with the difference in both cases being less than 0.1 M. The cost at KSC for changes in Launch Complex 37B between launches of AAP-2 and AAP-4 is about 0.5 M. The total cost for three jettisonable enclosures using the Apollo SLA as the base is about 6.6 M. The unit recurring cost is about 1.2 M and therefore five units would cost approximately 9.0 M.

MSFC proposes to build the 203 type enclosure in-house. If this proposal is realized, design and manufacturing costs, with the exception of minor procurements and materials, are absorbed in Center overhead. MSFC estimates that new GSE and test equipment will cost 0.6 M. Tooling for the cylindrical sections is estimated at 0.16 M. Each unit costs about 0.3 M. The cost of re-analysis of structural capabilities of the Airlock Module at McDonnell will be about 0.5 M, and new acoustic test equipment for MSC will be on the order of .25 M. The total cost of the Marshall program is therefore about 2.4 M based on three units, and 3.0 M based on five units.

In total cost to the Apollo Applications program, the Marshall proposal for one test and two flight units could save a total of about 4.2 million dollars. For one test and four flight units, the saving is about 6 million.

Trade Off

The decision as to which of the contenders should be accepted can be made by answering whether or not 600 to 1200 pounds additional payload into orbit, split between AAP-2 and AAP-4, is worth the 4.2 million dollars additional cost of the SLA. This works out to be 3,500 to 7,000 dollars per pound. For four unmanned launches, the figures are 2,500 to 5,000 dollars per pound.

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1022-WWH-jdc W. W. Hough

BELLCOMM, INC.

Subject: Jettisonable Enclosure for Unmanned AAP Payloads

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